

INSTRUCTION MANUAL



NO. IN 1211.3-7A
(FORMERLY 6407A)

Capacitrols

model 407P

BARBER-COLMAN COMPANY

Industrial Instruments Division • Rockford, Ill., U.S.A.

INDEX

INSTRUCTION MANUAL — MODEL 407P INDICATING CONTROLLER

Unpacking Instrument	3
Mounting Instructions.....	3
Mounting Dimensions	4
Power Wiring.....	4
Thermocouple Wiring	5
Meter Shunt Wire.....	5
Line Compensating Resistor.....	6
Thermocouple Break Protection (TCB).....	6
Meter Adjustment and Check.....	7
Description of Electronic Circuit.....	7
Manual Reset.....	8
Proportional Control.....	8
Process Control Systems.....	8
Reactor Wiring.....	9
Pilot Amplifiers.....	10
Initial Control Start-Up Adjustments.....	10
Model 407P Maintenance and Service Checks.....	11
Internal Wiring Diagram.....	12 and 13
Suggested Replacement Parts.....	14
Thermocouples	14
Warranty.....	15

NOTE: This instruction manual to be given to persons responsible for installation and maintenance of this instrument.

UNPACKING INSTRUMENT

This precision instrument and its associated equipment have been carefully manufactured and packed at the factory. Remove the instrument and accessories from the packing box and check items against the packing slip. If the equipment is found to be damaged in transit, report extent of damage to the carrier immediately. Repack in original packing box until ready for installation.

CAUTION:

Handle with care.

Safeguard instrument from shock.

Avoid oil accumulation.

Keep instrument temperature under 130° F.



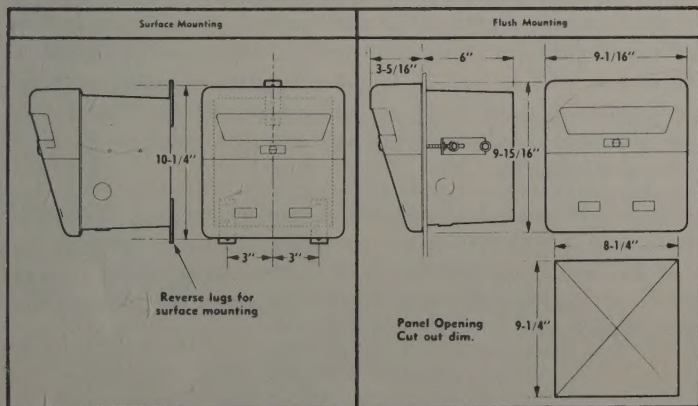
MOUNTING INSTRUCTIONS

Locate the instrument to avoid shock, excessive vibration, moisture and temperatures over 130° F. Avoid furnace walls, radiation of heat, machine frames and outside walls. Provide suitable shelter to avoid moisture and temperature extremes if installed outdoors.

For surface mounting, attach the three lugs (provided) to the back of the instrument housing. See the surface mounting dimension drawing.

For flush or panel mounting, remove the angle brackets from the cloth bag, insert the instrument through the panel opening, attach brackets to the side of the instrument housing and tighten firmly. See the flush mounting dimension drawing.

MOUNTING DIMENSIONS

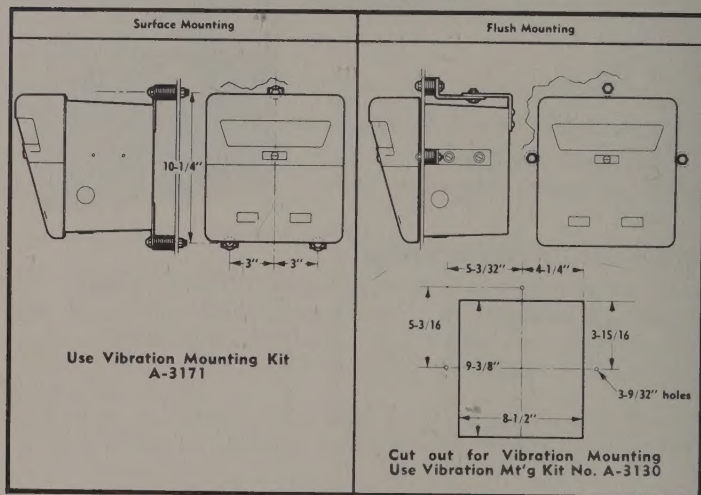


Vibration mounting kits should be used if the vibration causes erratic temperature readings or control. See the vibration mounting dimension drawing for details of surface or flush mounting. Special provisions may have to be considered if the instrument is subjected to severe shock such as from a drop forge or similar type of equipment.

Moderate care should be taken to mount the instrument level.

MOUNTING DIMENSIONS

Vibration Mountings



POWER WIRING

Remove the lower section of the front cover to expose the terminal strips and the control chassis. To expedite wiring, grasp the side plates of the chassis and pull forward to remove. Check the rating plate on the chassis for the supply voltage and frequency. Connect proper voltage and frequency to terminals L1 and L2. Supply voltage should be 110 to 130 volts AC or 220 to 260 volts AC depending on chassis specifications. Run all wiring in rigid conduit, BX or Greenfield, in accordance with the recommended electrical code. Use properly fused switches, see diagram.

Solid wire (14 ga.) is recommended for instrument wiring. If stranded wire is used, tin the ends to provide secure connections. Position the wires so they do not interfere with control chassis or the housing gaskets. Ground the instrument case; a grounded conduit system is usually sufficient.

To alter the control chassis in the field for different line voltages, change the transformer primary connections in the chassis per following:

- 240 volt** Solder red wire to chassis pin 10, (L2) green-yellow wire to chassis pin 12, (L1). Solder red-white wire to green wire and tape connection.
- 208 volt** Same as above except solder green-red wire to chassis pin 12 (L1) and attach solderless wire connector to free end of the 240 volt tap.
- 120 volt** Solder red and green wires to chassis pin 10, (L2). Solder red-white and green-yellow wires to chassis pin 12, (L1). See internal wiring diagram page 13.

THERMOCOUPLE WIRING

Do not run thermocouple lead wire with other power or control wiring except for thermocouple break (TCB) wires, if used. Several thermocouple lead wires may be run in the same conduit if desired.

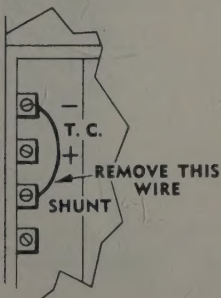
Use only extension lead wire correct for the type of thermocouple (TC) as specified on the scale. The most commonly used types are: iron-constantan (I/C), chromel-alumel (C/A), platinum-platinum 10% rhodium (Pt/Pt 10% Rh), platinum-platinum 13% rhodium (Pt/Pt 13% Rh) and Heat-Eye. Ordinary copper wire will NOT serve the purpose.

Proper polarity (+) and (—) of the lead wire must be observed to obtain correct readings. The negative wire is usually coded red. Correct polarity of the lead wire can be checked by heating a temporary junction of the lead wire far end. Deflection of the indicator upscale indicates correct polarity of the lead wire.

The thermocouple should then be connected to the lead wire and the indicating pointer should again deflect upscale when the thermocouple hot junction is heated. If the indicator moves downscale, reverse only the connections at the thermocouple head since the lead wire has already been correctly connected to the instrument.

Secure the lead wire firmly under the terminal screw head. If desired, spade lugs may be used. Locate the lead wire so it does not interfere with the control chassis or housing gaskets.

METER SHUNT WIRE



After the instrument is installed, disconnect the jumper wire across terminals "Shunt" and "TC—". This wire is used to shunt or dampen the meter movement for protection during shipping, installation and handling of the instrument but should be removed for normal operation.

NOTE: Replace this shunt wire when handling or reshipping the instrument and position the red control point indicator to the top of the scale.

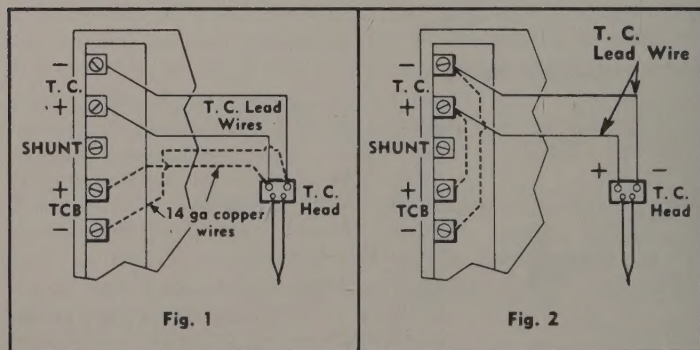
LINE COMPENSATING RESISTOR (KIT A-3497)

The external resistance, combined resistance of the extension lead wire and thermocouple, for which the meter has been calibrated is marked on the meter scale. Most meters are calibrated for 15 ohms (Ext. Res. 15 ohms) which is more resistance than most lead wire runs. The balance of the resistance, 15 ohms minus the actual external resistance, will be inserted on a removable resistance strip located just under the meter section. The resistance value is marked on the strip and is inserted at the time of the original order. Other values are available, however, lead wire length can be changed up to 25 ft. without appreciable error in reading because a high resistance movement is used.

THERMOCOUPLE BREAK PROTECTION (TCB)

The instrument is equipped with thermocouple break (TCB) protection. Essentially it is a small DC voltage that can be wired into the thermocouple circuit to drive the movement upscale in case of an open circuit in the thermocouple, thus passing the control set point and causing the instrument control to go to the off position. It is not necessary to make the TCB connections for normal operation of the instrument, but its use may be desirable on some applications to guard against overheating in event of an open thermocouple.

The preferred method of connecting TCB is shown in Fig. 1. Use extension lead wire as required to make the connections between the instrument T/C terminals and the thermocouple head. Use 14 gauge copper wire to connect the TCB terminals to the thermocouple head, observing polarity. Wiring for TCB may be run in the same conduit with thermocouple lead wire. As the resistance of the thermocouple is low compared to the resistance of the meter movement, TCB compensation is seldom required.



METER ADJUSTMENTS AND CHECK

After the instrument is mounted, check for the cold junction reading of the meter. Disconnect the lead wire at the instrument. The indicator should come to rest at the ambient temperature of the meter; it is NOT supposed to read zero. Place a thermometer at the T/C instrument terminals to read ambient temperature.

If the pointer does not come to rest at the ambient temperature, slowly adjust the screw located on top of the front plastic cover. As the meter has automatic cold junction compensation, it is not necessary to make further corrections as the ambient temperature changes.

To check for thermocouple break error (TCB) if it is connected, it is best to have a steady temperature at the hot junction of the thermocouple. Read the temperature at the indicator. For exact reading, position the eye so the reflected image of the pointer on the mirrored strip disappears behind the pointer itself. This reading to be made with power on the instrument. Then disconnect power to the instrument, remove the control chassis, or disconnect the wires at the TCB terminals and note if the indicated temperature drops. Reconnect to see if temperature rises. If a shift in reading is noticed, usually a small amount if any, adjust the screw on the top of the plastic cover, so the reading with TCB powered is at the same point as read with TCB disconnected. If an adjustment was made, the ambient temperature reading will also shift a like amount.

DESCRIPTION OF ELECTRONIC CIRCUIT

The Model 407P is a modification of the basic "400" Series control family. The familiar Electronic Link principle is incorporated here to sense the position of the meter pointer in respect to the control set point. The "400" Series employs the simple tuned grid, tuned cathode oscillator as a means of obtaining correct amplifier voltage output.

When the vane carried by the temperature pointer passes upscale between the pickup coils mounted on the set point control segment, the circuit goes into oscillation and prevents the tube from conducting, decreasing the amplifier voltage output. This action causes the reactor to desaturate, decreasing the power to the load.

The amplifier output is controlled between 6 volts, minimum output, to 90 volts, maximum output, depending on flag position and proportional band adjustment. This voltage is conveniently measured at the red and black twin jacks on top of the plug-in chassis. (Red +, Black —). Note: Use a voltmeter of 10,000-ohm per volt sensitivity or better.

The control chassis is designed to "plug-in" to the instrument compartment providing excellent servicing arrangement or for changing to other modes of control as provided in the "400" Series.

The control point setting knob is located directly beneath the instrument scale and is easily adjustable but protected against accidental shifting. The model number will be found on the control point set knob.

The green signal lamp is powered from the transformer secondary and indicates power on the chassis.

MANUAL RESET

The re-alignment of the meter pointer with the set pointer is readily adjustable by positioning of the tuning condenser on the control chassis. Using a small screwdriver, turn clockwise to lower the point of control and counterclockwise to raise the point of control.

PROPORTIONAL CONTROL

The proportional control band (throttling range) is conveniently adjusted by positioning of the "PROP. BAND" dial on the left side of the chassis front. The band is narrowed by turning the dial clockwise and widened when rotated counterclockwise. The proportional band is fully adjustable between .5 and 5.0% of meter span.

PROCESS CONTROL SYSTEMS

The direct current output of the Model 407P can be used for the proportional control of large amounts of electric power through use of a Saturable Reactor or one of the Series 620 "SCR" Power Controllers. When using a Saturable Reactor, a Pilot Amplifier is needed to amplify the signal to an amount required for input to the Reactor. The output of the Model 407P is fed directly into the Series 620. (See figures 4, 5 and 6 for typical external wiring arrangements). For a description of Reactors or Power Controllers, and specifications of models available, contact the factory or Barber-Colman representative.

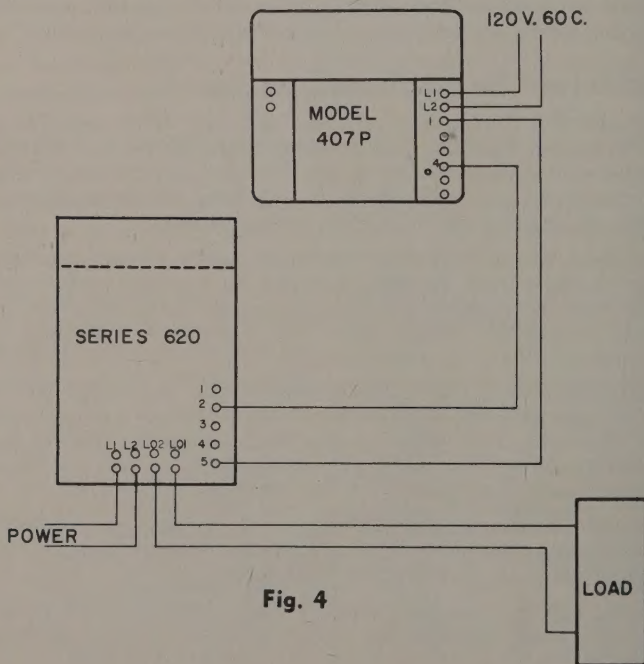
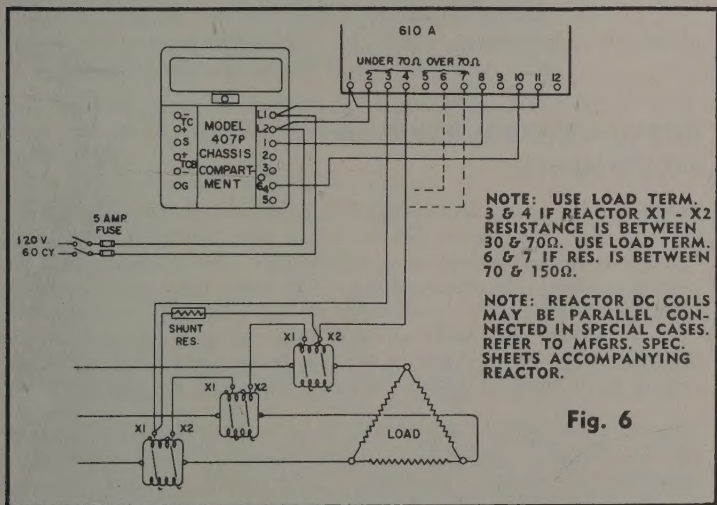
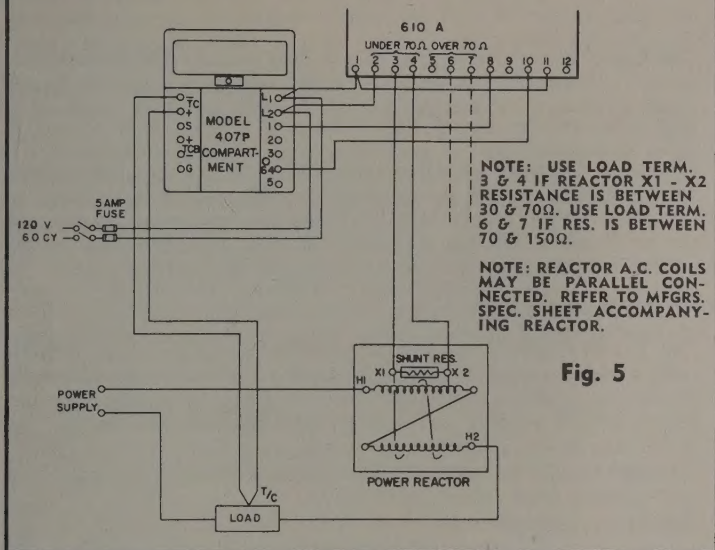


Fig. 4



EXTERNAL WIRING CONNECTIONS USING MODEL 610A PILOT AMPLIFIER AND SATURABLE REACTOR

REACTOR WIRING

In the event that the external control circuit of the reactor should accidentally open while the reactor is under load, an extremely high voltage could be induced in the control winding. This could damage the internal insulation as well as being a safety hazard. It is recommended that a shunting resistor be connected directly at the reactor terminals. This resistor is supplied connected to X1 and X2 of the reactor control windings.

The load circuit of the reactor is connected in accordance with manufacturer's instructions accompanying the equipment, however, figures 5 and 6 show typical wiring schemes for single and three phase applications.

The small meter in the pilot amplifier can be used to approximate the percentage of total reactor load, the 100 reading being equal to maximum power reactor output. When the equipment is powered, the small meter will not read down to zero with minimum reactor output, as the reactor does not completely cut load voltage to zero.

PILOT AMPLIFIERS

Two models of pilot amplifiers are available. The Model 610A is essentially a magnetic amplifier utilizing a small saturable core reactor and dry rectifiers to provide a controllable d-c current used to saturate the power reactor control winding. It is used to drive saturable reactors up to 30 KVA. The Model 630A Pilot uses silicon controlled rectifiers driven by a magnetic amplifier to provide high response linear output capable of driving single phase reactors to 150 KVA.

SPECIFICATIONS:

Model 610A: line voltage 120V, 60C; output 5-75 vdc, maximum power 188 VA on reactor windings. Reactor capacity 0-30 KVA.

Model 630A: line voltage 120V, 60C; nominal output 500 VA. Maximum output 80 vdc at 6 amperes. Reactor capacity to 130 KVA.

INITIAL CONTROL START-UP

ADJUSTMENTS

When the wiring has been properly completed and the equipment is ready to start, turn on the power. Adjust the "PROP. BAND" knob (proportional band width) to middle position. Set the red control set pointer so that it is directly in line or in coincidence with the black indicator. Observing the small meter on the pilot amplifier, or power controller, adjust the RESET so the small meter reads approximately at midscale or 50. As the temperature may be changing while adjusting, recheck coincidence of the red and black pointers of the Model 407P.

After the temperature is leveled off at a steady value, note the position of the temperature in relation to the control set pointer. Rotate the "Man. Reset Adj." clockwise to lower and counter clockwise to raise the controlled temperature, to align the two pointers. Upon observing temperature deviations due to load changes, slowly turn the "PROP. BAND" adjustment clockwise to obtain cycling. Back off counter clockwise until cycling is no longer present. This point will depend upon furnace capacities and heat rates and must be determined for each individual installation. The throttling range band is adjustable between approximately $\frac{1}{2}$ and 5% of scale. Note: The "Man. Reset" may need to be repositioned slightly to realign the temperature pointer with the control point after the optimum "PROP. BAND" position has been set.

MODEL 407P

MAINTENANCE AND SERVICE CHECKS

While the 407P Series instrument is well designed and manufactured of high grade components, it is worthwhile to have information as to service and spare parts for emergency servicing. Where a number of instruments are located together, the plug-in parts are interchangeable and allows a minimum inventory.

Upon experiencing a trouble complaint, the serviceman should familiarize himself with the process and instrument application to ascertain the exact function of the instrument as applied. The instrument trouble usually can be traced to two basic problems, measurement or control.

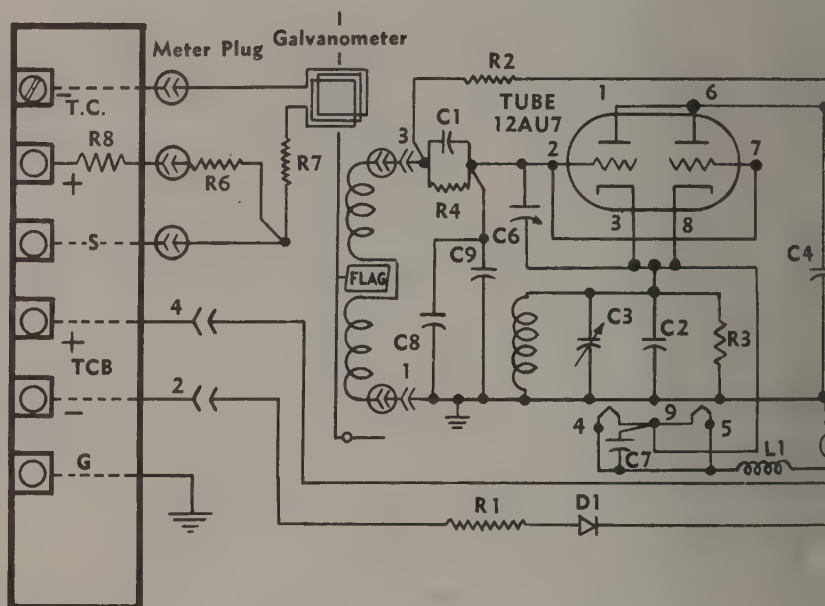
Measurement trouble can be detected by observing the pointer position.

If the measured temperature is known to be in error, check the following:

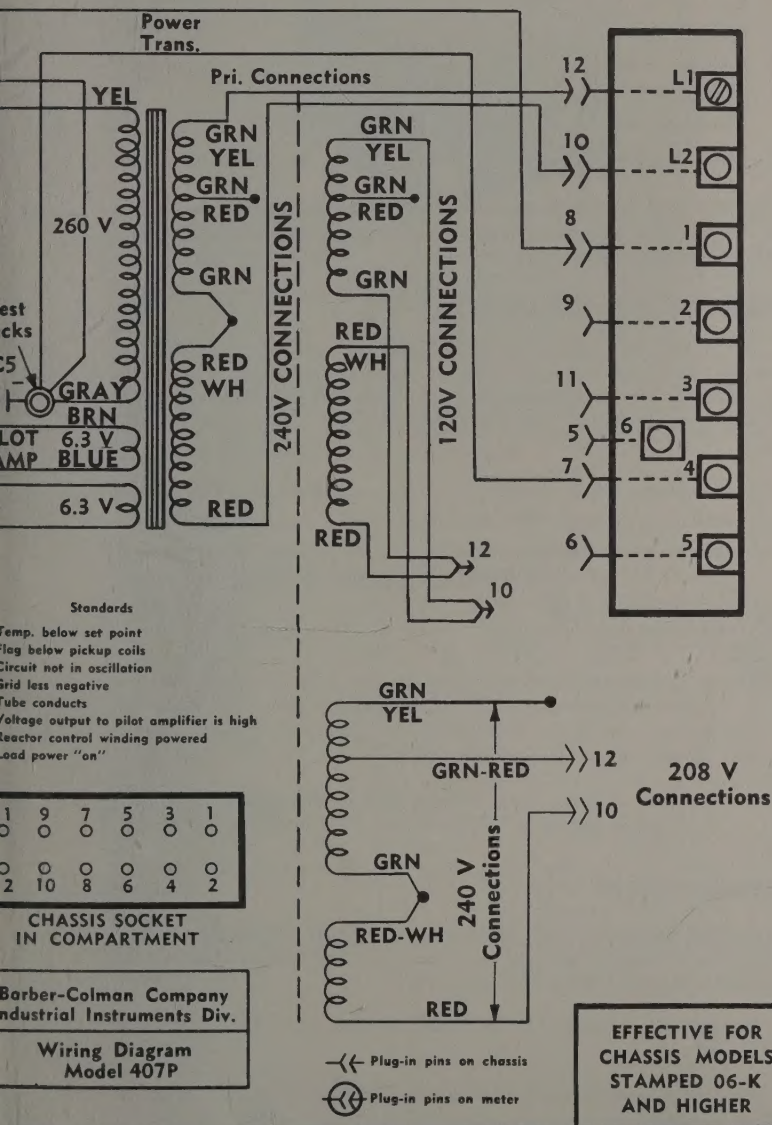
- (1) Open thermocouple circuit, such as break in thermocouple or lead wiring.
- (2) Deteriorated T.C. hot junction due to burning.
- (3) Multiple shorts or grounds creating erroneous cold junctions.
- (4) High resistance in leads due to loose connections, dirty switch contacts, poor splicing, and other faulty connections.
- (5) Check for vibration or shock.

Control trouble may be detected by observing control point and indicated temperature position. If the temperature is not at the control point check:

- (1) Adjust manual reset to align pointers.
- (2) Check power input for low maximums if temperature will not rise to control point.
- (3) Check power input for high minimums if temperature will not hold to control point. Minimum load voltage, 17% of line voltage.
- (4) Is load matched to reactor size?
- (5) Determine if instrument and pilot amplifier are powered; check load power for open circuits and open legs in three phase circuits.
- (6) Measure output potential at instrument or pilot amplifier input terminals. Check the output of the Model 407P by connecting a DC voltmeter to the red and black jacks on chassis, measuring amplifier output. When the black indicator is well below the red control set pointer, the testmeter should read between 80 and 105 volts DC. When the black indicator is above the red control set pointer, the testmeter should read 10 volts DC or less. Replace tube if above readings are not obtained.
- (7) Replace electronic tube.
- (8) Replace chassis.
- (9) Check for excessive vibrations.
- (10) Measure supply for low voltages. Common low voltage to all components will cause large variations in available power to load.



R1	27 K, $\pm 10\%$, $\frac{1}{2}$ W	CYZR-170-7
R2	8.2 meg, $\pm 10\%$, $\frac{1}{2}$ W	40-089
R3	2.2 K, $\pm 10\%$, $\frac{1}{2}$ W	40-062
R4	4.7 meg, $\pm 10\%$, $\frac{1}{2}$ W	CYZR-170-18
R6	Range-Multiplier Res.	A-1847
	Specify type range and inst. ser. no.	
R7	Neg. Temp. Coeff. Assy.	A-3049-1
R8	External Res. Comp. Res.	A-3497
C1	.02 mfd, 600 VDCW, GMV	39-062
C2	75 mmf, 600 VDCW, NPO	39-125
C3	8-50 mmf variable cap.	39-105
C4	.005 mfd, 1000 VDCW, GMV	39-172
C5	8 mfd, 25.0 VDCW	CYZR-327-1
C6	3-35 mmf variable cap.	39-160
C7	.001 mfd, 600 VDCW, GMV	39-063
C8	12 mmf, $\pm 5\%$ 500 VDCW, N750	39-107
C9	5 mmf, $\pm 10\%$, N470	39-084
L1	Filament Choke	41-124
D1	Selenium Rectifier	37-009



In event it is found necessary to remove the meter assembly, follow steps below. This is a plug-in assembly.

- (1) Remove set point adjustment knob (Bristol No. 6 wrench).
- (2) Remove four cover screws.
- (3) Remove cover straight forward to prevent damage to internal meter parts.
- (4) Loosen screws in lower meter chassis corners.
- (5) Insert fingers behind pulling lugs and pull very gently.

Reassembly is of reverse procedure being careful to line up the slotted lever for the zero adjustment pin when installing gasketed cover. Reinstall set point knob.

SUGGESTED REPLACEMENT PARTS

It is recommended that a few spare parts be carried by the user to insure against possible emergencies and accidental damage. We do not recommend electronic components replacement except by well equipped instrument repair shops. The following parts are recommended to be carried:

- *1—Electronic tube (12AU7) Part No. EYZP-70-9
- 1—Mazda pilot lamp (#51 blue bead) Part No. 36-022
- 1—Model 407P control chassis Part No. A-3619-1
specify by instrument serial number and voltage.
- 1—Replacement thermocouple
(See original order)

*NOTE: It is recommended to purchase the 12AU7 tube from the Industrial Instruments Division, Barber-Colman Company to insure instrument functioning as designed. Tubes are purchased under rigid specifications.

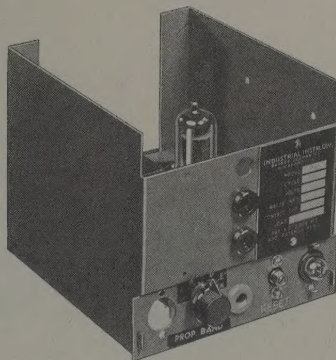
A more rugged industrial tube is available which has a normal life in excess of 10,000 hours. Order tube No. 5814.

THERMOCOUPLES

To help you select the best thermocouples for any of your needs, two comprehensive catalogs are available to you without charge. Write to the factory or call your nearest representative.

— — For general purpose thermocouples, request Data Book and Catalog TC-13A.

— — For thermocouples used primarily in the Plastics Industry, request Catalog TC-13B.



MATERIAL WARRANTY: All equipment except tubes, photocells, and thermocouples, which within one year from date of shipment is found to have been originally defective, will be repaired (replaced if necessary) free of charge, if returned immediately, prepaid to the factory at Rockford, Illinois. The seller shall not be liable to the purchaser, or to any other person, firm or corporation for any direct, indirect or consequential damages or injury of any kind or character; that by acceptance of such equipment the purchaser shall accept and assume all liability for any and all damages or injuries that may result from the use or misuse of such equipment by the purchaser, or by any other person, firm or corporation; and that there shall be no other warranty whatever, expressed or implied, with respect to such equipment.

Warranty and Inspection Card

This equipment is guaranteed in accordance with the statement of warranty appearing on our quotation and acknowledgement forms. Upon receipt of this card properly filled out Warranty becomes effective. All Barber-Colman Instruments are manufactured to the highest standards of quality and are carefully inspected before packing. Instruments which have been damaged or fail to operate upon installation, should be reported to the Factory at once.

BARBER-COLMAN COMPANY
Industrial Instruments Division

MODEL NO.	Date Received		
SERIAL NO.	Company		
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FINAL INSPECTION	City	Zone	State
	By	Title	
	COMMENTS		

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